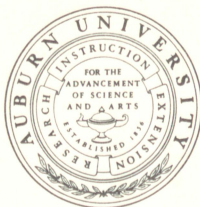


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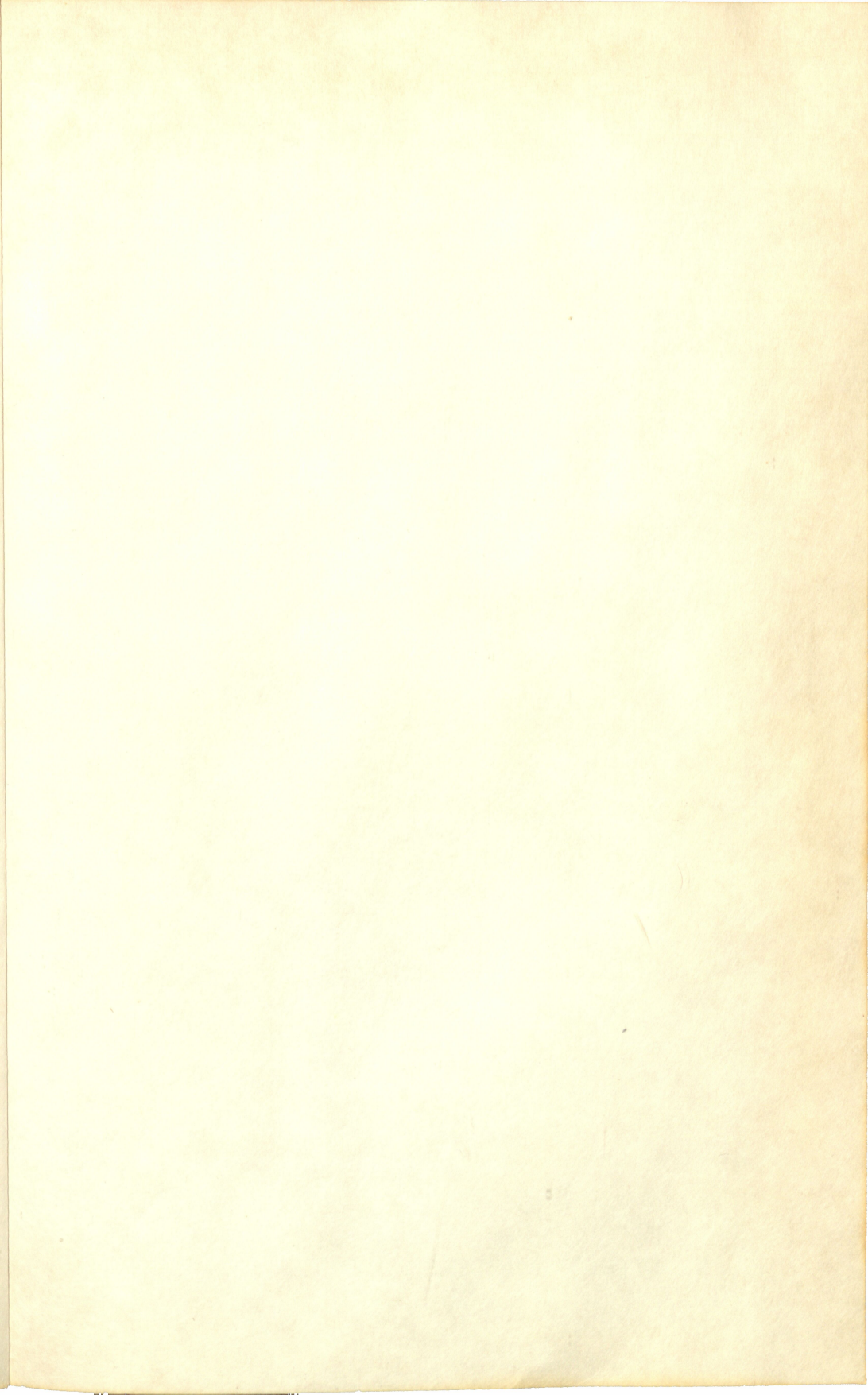
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LETTER OF TRANSMITTAL

University, Alabama

June 27, 1947

Honorable James E. Folsom
Governor of Alabama
Montgomery, Alabama

Sir:

I have the honor to transmit herewith the manuscript of a report entitled, "Ground-Water Investigations in the Mobile Area, Alabama" by Carl G. B. Peterson, of the United States Geological Survey. It is requested that it be printed as Bulletin 58 of the Geological Survey of Alabama.

Respectfully,

WALTER B. JONES

State Geologist

GROUND-WATER INVESTIGATIONS IN THE MOBILE AREA,
ALABAMA

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GROUND-WATER INVESTIGATIONS IN THE MOBILE AREA, ALABAMA

By CARL G. B. PETERSON

Abstract

As part of the studies made by the Geological Survey, United States Department of the Interior, in cooperation with the Alabama Geological Survey, an investigation of the ground-water conditions was made in the Mobile area, Alabama. This report gives some of the results of the investigations of the salt-water encroachment in the shallow aquifer penetrated by wells 25 to 90 feet deep in the area. Data on other formations to a depth of 850 feet are included.

The area considered is in the downtown business section of the City of Mobile. The shallow aquifer yielded an adequate and satisfactory water supply for air-conditioning equipment for many years before the encroachment of salt water. Aquifers that are deeper have not increased in salt content.

In the vicinity of Mobile the average annual rainfall is 62 inches, and favorable geological conditions exist for intake of water into the shallow aquifer. Pumpage from the shallow aquifer has decreased, owing to the increase of the chloride content of the water. Also, additional decreases in pumping the shallow aquifer are planned. These changes, coupled with the large intake of rainfall, are tending to flush the salt water from the aquifer. The deep aquifers may be used for air-conditioning units that require large quantities of ground water. Artificial recharge to the shallow aquifer may be helpful under favorable conditions.

INTRODUCTION

In the downtown area of Mobile, water from the shallow aquifer penetrated by wells 25 to 90 feet deep is used extensively for air-conditioning. However, the chloride content of the water has increased (pl. 1, table 2), and some of the users of the water from these shallow sands have been compelled to abandon their wells. An early publication on "Underground Water Resources of Alabama" by E. A. Smith¹ furnished ground-

¹Smith, E. A., Underground water resources of Alabama, Geological Survey of Alabama, pp. 307-311. 1907.

water information for the Mobile area. Further investigations of the ground-water conditions in the vicinity of Mobile were carried on in the spring of 1942 by C. W. Carlston, of the United States Geological Survey, working in cooperation with the Alabama Geological Survey. Mr. Carlston collected much of the data used in this report. The investigation was continued by the author in the summer of 1945 under the direction of P. E. LaMoreaux, and observations are still being made to obtain a record of changes in chloride content of the water.

Acknowledgment is made of the aid and cooperation of Dr. Walter B. Jones, State Geologist of Alabama. The manuscript has benefited from the suggestions of O. E. Meinzer, A. N. Sayre, V. T. Stringfield, C. E. Jacob, W. D. Collins, and P. E. LaMoreaux, all of the United States Geological Survey.

Among the many business and professional men of the area who have helped in this study are the late G. M. White, treasurer, Gulf, Mobile and Ohio Railroad; E. D. Adams, building superintendent, Gulf, Mobile and Ohio Railroad; H. S. Aldridge, building manager, First National Bank; E. M. Stickney, superintendent, Mobile Water Works; A. E. Stuardi, building manager, Merchants National Bank; F. B. Smith, engineer, Hollingsworth-Whitney Company; and G. S. Mabrey, chief chemist, Southern Kraft Corporation.

The information obtained from well drillers has been valuable in the interpretation of the ground-water conditions of the area. The writer is particularly indebted to W. M. Boswell and H. C. Knowles, Deep Well Drilling Company, Foley; M. J. Gray, Gray Artesian Well Company, Pensacola, Florida; and Elmer Cerecy, Carlross Well Drilling Company, Mobile.

HISTORY OF MOBILE WATER SUPPLY

During the early years of Mobile, water supplies were hauled from the creeks north of the city. On December 26, 1840, the city authorities signed a water service franchise with Albert Stein, a consulting engineer of New Orleans. Mr. Stein constructed a waterworks on Three Mile Creek, from which Mobile was supplied water until 1898. In 1886 the Bienville Water Supply Company constructed a pumping station on Clear Creek and operated it as a unit separate from the Stein system. In 1898

the City acquired the Stein property and in 1907 the Bienville waterworks, thereby gaining complete municipal ownership of the Mobile water-supply system. Since 1907 the City has operated the water works, making improvements as population and industry have increased. At present, plans are being made for increasing the city supply.²

Although the city has supplied the greater part of water for domestic and industrial needs, many shallow and a few deep wells have been made and are in use by individuals in the area. Ground water was used commercially in the city before 1900 in breweries and for the manufacture of ice. Air-conditioning units were installed in many of the downtown business houses in 1937 or thereabouts. These installations pumped water from shallow wells.

Maximum use of these shallow wells occurred about 1942, when heavy withdrawals of ground water caused the encroachment of salt water into parts of the shallow aquifer. A year later, in 1943, additional wells were drilled to the deeper aquifer and in some places this aquifer has proved to be satisfactory for large business establishments.

GEOGRAPHY AND CLIMATE

Mobile is in southwest Alabama on the west side of the Mobile River at its entrance into Mobile Bay, about 30 miles north of the Gulf of Mexico. Over most of the industrial and business district of the city, the land surface is not more than 15 feet above mean sea level, but it rises gradually to 30 feet along the western edge of the city. North and south of Mobile are low marshes that are indented by many tidewater creeks. The main streams are Big Bayou, Chickasaw Creek, Threemile Creek, and Dog River.

The population of greater Mobile, according to the Census of 1940, was 115,000. However, owing to the labor demands of shipbuilding and other war industries, the population of greater Mobile had increased to approximately 190,000 by the end of 1945, according to estimates made by the Mobile Chamber

²Stickney, E. M., Present and proposed water supply, domestic and industrial, Waterworks Department, Mobile, Alabama, July 11, 1946; typewritten report submitted to the City of Mobile.

of Commerce. Mobile is the only seaport in Alabama that has harbor facilities accommodating coastwise and seagoing vessels. Shipbuilding and the repairing of ships form one of the principal industries; other important industries are the manufacture of textiles, paper, and lumber and the refining of bauxite. Excellent transportation systems are available, as Mobile is served by ocean steamship lines, five railroads, three major commercial airlines, an intercoastal waterway, and numerous highways.

The climate of Mobile is subtropical, with an average annual rainfall of nearly 62 inches, evenly distributed throughout the year. The summers are long, generally warm, and rather humid; whereas the winters are short and mild, with only occasional short periods of sub-freezing temperatures accompanied by killing frosts.

The average monthly rainfall and the lowest and highest temperatures on record at the U. S. Weather Bureau at the Mobile station are shown in the following tables:

Mean precipitation at Mobile

(65-year record)

Month	Inches	Month	Inches
January	4.85	July	6.89
February	5.52	August	6.92
March	5.98	September	5.00
April	4.63	October	3.60
May	4.32	November	3.64
June	5.43	December	5.92
		Total	62.70

Lowest and highest temperatures on record at Mobile

(Degrees Fahrenheit)

(59-year record)

Month	Lowest Temperature	Highest Temperature
January	11	78
February	-1	81
March	25	91
April	32	90
May	44	98
June	50	101
July	62	103
August	57	101
September	48	103
October	34	95
November	25	84
December	14	80

GEOLOGIC FORMATIONS

Mobile is underlain by terrace and alluvial deposits in the flood plain of the Mobile River at an elevation of 5 to 30 feet above sea level. West of the city the hills rise to an elevation of 200 feet and are capped by the sand, gravel, and lenticular white to variegated clay of the Citronelle formation of Pliocene or early Pleistocene age. As shown on the recent geologic map published by the U. S. Geological Survey³, the Citronelle formation is underlain unconformably by tough sandstones, variegated argillaceous sand, and dark variegated clay of Miocene age. The downcutting of the Mobile River in the Mobile area reduced the land surface below the base of the Citronelle so that the alluvial deposits probably lie disconformably on sediments of Miocene age.

The upper part of the alluvial deposits consists of decayed trees, vegetal matter, and carbonaceous clay. The clay grades downward into fine argillaceous sand, coarse sand, and gravel, interbedded with lenticular clay beds. The basal beds of the alluvium, generally of coarse gravel, disconformably overlie the estuarine Miocene deposits. Wells in the Mobile area usually

³MacNeil, F. S., Geologic map of the Tertiary formations of Alabama: U. S. Geol. Survey Oil and Gas Investigations, Preliminary map 45, 1946.

encounter 80 to 150 feet of river alluvium before penetrating the underlying Miocene beds.

The Miocene deposits, which extend below the bottoms of the deepest water wells in Mobile, probably to a depth of 1,300 to 1,400 feet, consist of gray dense clay, sandy clay, fine argillaceous sand, and medium to coarse sand, with a gravelly sand about 300 feet thick at the base. Clay makes up the greater part of the Miocene deposits penetrated by water wells at Mobile. The sand and clay beds are highly lenticular, and it has not been possible to make correlations of all water-bearing beds from one well to another. The Miocene deposits have a regional dip slightly west of south in Mobile County, and at surface exposures in the outcrop area north of Mobile they appear to dip 15 to 25 feet per mile. In the subsurface the Miocene seems to thicken rapidly downdip.

Logs of four wells—well 61, Mobile Brewery; well 5, G. M. & O. Building; and wells 32 and 34, Alabama United Ice Company—were chosen to illustrate the geology of the shallow and deep aquifers now used in Mobile as a source of water for air-conditioning units. The logs for wells 32, 34, and 61 are drillers' logs from which the geology has been interpreted. The hard shale and soapstone in wells 32 and 34 are probably either hard sandstones or compact clay of the Miocene, and the gumbo is a less compact clay of the same age. The log for well 5 at the G. M. & O. Building is based on the samples from this well. The wells illustrated in figure 1 are aligned down the dip from well 61 to well 34. The bottom of the shallow aquifer, which is probably limited to the alluvium of the Mobile River, is assumed to be at the top of the first persistent thick clay layer above which lies material of alluvial origin as described in the drillers' logs. The position of the top of the deep water-bearing sand is shown by the depth at which the deep wells develop their water supply.

The logs, as illustrated in figure 1, show the terrace and flood-plain deposits that were laid down when the Mobile River and tidal waters inundated this area. Because the alluvial deposits are irregular, there is considerable variation in thickness and lithology even within short distances, as shown by closely-spaced wells.

The deposits of Miocene age underlying the alluvium are

more persistent, having been deposited under less variable geologic conditions. However, these beds cannot be correlated in every case.

GROUND WATER

Precipitation that falls on the surface of the ground is distributed in three ways: (1) part of it is evaporated and returned to the atmosphere; (2) part flows over the surface and runs off in streams; and (3) the rest percolates downward through the soil and collects in void spaces beneath the land surface. That part of the water which enters the soil and is not later evaporated eventually collects below the water table in the interstices of the rocks and is called ground water. This water may be recovered from wells or springs. The ground-water that is not withdrawn artificially eventually reaches points of natural discharge into bodies of surface water.

Rocks differ widely in their porosity and in their permeability. The most productive aquifers are those having high porosity and high permeability, such as gravels and cavernous limestones. Sands and sandstones have moderate porosity and yield moderate amounts of water to wells. Clays are generally high in porosity, but their permeability is so low that they yield very little water to wells.

The volume of water that can be safely withdrawn from an aquifer depends on the quantity of water that is recharged to replace the withdrawal. If the quantity of water pumped from the aquifer exceeds the quantity recharged, the deficiency is supplied from storage. Excessive withdrawals can continue only until the water in storage is depleted.

In the deeper productive horizon the water is confined by impervious strata both above and below the water-bearing formation. The weight of water in the aquifer up dip from the well exerts a pressure at the well. The amount of pressure exerted by this head of water theoretically is directly proportional to the difference in the elevation of the aquifer at the well and the elevation of the aquifer at the intake area minus the loss in head due to friction. The head of water at a given point in an aquifer is expressed as the height of a column of water that can

be supported by the hydrostatic pressure. Thus, water will rise in a well tapping an artesian formation above the confining layer overlying the aquifer. If the head is sufficient the water will flow above the surface of the ground (fig. 3). The downtown area of Mobile is an area of artesian flow from wells tapping the 700- to 800-foot aquifer. The dip of this formation indicates that the intake area for this aquifer is many miles north of Mobile. Water entering the formation in the intake area may require many years to reach wells in downtown Mobile.

According to the information obtained during the recent study, the deep flowing wells, 700 to 800 feet deep, have not experienced an appreciable decline in pressure or change in yield. Although the water has a rather high chloride content (table 3), its use in large air-conditioning and condensing units has proved to be satisfactory.

Water-table conditions exist in the shallow aquifer in the downtown Mobile area. The water in wells 25 to 90 feet deep is unconfined and does not rise above the level at which it is struck. These sand and gravel beds yield water with a temperature of 70 to 73° F., that is used for air-conditioning. Pumping tests were not made to determine the permeability and the storage capacity, but records of pumpage for air-conditioning during 1942 show that about 2 million gallons per day was pumped from the aquifer within a small area in downtown Mobile. The safe yield of the existing well system was exceeded and withdrawal from storage lowered the water table below the level of the Mobile River.

ENCROACHMENT OF SALT WATER

Salt water from the Gulf of Mexico flows into Mobile Bay and into Mobile River and its tributaries as a wedge extending upstream along the river bottom beneath the fresh water, which flows downstream. This salt water is seeking the level of the sea. Its flow upstream is retarded when the flow of fresh water is increased. The United States Army Engineers of the Mobile District have conducted a salinity survey of the Mobile River and some of its tributaries to determine the extent to which sea water intrudes upstream in this manner. Five stations, called "ranges," were located at strategic positions along

the streams to obtain this information; one on Mobile River, two on Big Bayou, one on Threemile Creek, and the other on Chickasaw Creek. (table 1) Range 3, not shown in table 1, is 11½ miles upstream from Mobile. Water samples were taken at these ranges periodically and analyzed for chloride content. The results of these tests available at the time of this investigation are shown in table 1. The data in the table represent a study of only a few months. Nevertheless, they show the intrusion of salt water from the Gulf of Mexico into Mobile River and its tributaries.

Fresh ground water is lighter than salt water and therefore floats on salt water, generally with a rather sharp line of separation unless the contact fluctuates in position in response to intermittent pumping or other causes, which causes the waters to diffuse. Studies of this relationship were made independently by Herzberg and Ghyben in Europe about 1890. Out of the investigations of these two men has grown the Ghyben-Herzberg theory. A review of their work was made by John S. Brown⁴, who applied the theory to his work in Connecticut. According to the Ghyben-Herzberg formula, which expresses the relation of the elevation of fresh water above sea level to the density of sea water, 1 foot of fresh ground water above sea level in the Mobile area means 60 feet of fresh water below sea level; that is, with a fresh-water head of 1 foot salt-water intrusion is prevented to a depth of 60 feet below sea level in this area. (Mobile River salt-water density is estimated to be 1.015.) Likewise, a 2-foot head of fresh water above sea level will prevent intrusion to a depth of 120 feet below sea level. However, the density of salt water in the river undoubtedly varies widely, so that the relation between fresh and salt water is much more complicated than suggested by the simple 1:60 ratio given above.

Table 4 gives partial chemical analyses of ground water from representative wells in the area under consideration. In the downtown area where salt water encroached into the shallow wells, the chloride ranged from 52 parts per million in a sample from well S-9 at the Morgan Plan Bank to 8,650 parts per million in a sample from well S-2 at Hammel's Department

⁴Brown, John S., A study of coastal ground water, with special reference to Connecticut: U. S. Geol. Survey Water Supply Paper 537, pp. 16-17, 1925.

TABLE 1
SALINITY IN MOBILE RIVER AND TRIBUTARIES¹

Date	Location	Range 1 ²		Range 2 ³		Range 4 ⁴		Range 5 ⁵	
		Depth (feet)	Chloride (ppm)	Depth (feet)	Chloride (ppm)	Depth (feet)	Chloride (ppm)	Depth (feet)	Chloride (ppm)
11- 9-44	Midstream	20.0	12,600	30.0	12,500	-----	-----	-----	-----
1- 4-45	Midstream	32.0	10,600	32.0	23	-----	-----	-----	-----
1-31-45	Midstream	16.0	970	27.0	20	-----	-----	-----	-----
2-14-45	Midstream	17.0	20	29.0	18	-----	-----	-----	-----
3- 7-45	Midstream	18.0	13	30.0	12	11.0	118	31.00	20
3-21-45	Midstream	18.0	11	28.0	11	7.0	51	36.00	22
4- 3-45	Midstream	21.0	11	32.0	10	-----	-----	-----	-----
4-11-45	Midstream	19.0	8	30.0	8	10.0	100	30.00	14.00
4-25-45	Midstream	19.00	13	30.00	12	10.00	31	40.00	10.00
5- 9-45	Midstream	10.0	10	31.0	8	10.00	160	37.00	15.00
5-23-45	Midstream	18.0	11	30.0	8	10.00	320	37.00	13.00
6- 6-45	Midstream	18.00	8,500	28.00	8,014	10.00	514	32.00	30
6-20-45	Midstream	17.0	850	28.0	3,740	8.00	80	38.00	28
7- 3-45	Midstream	18.0	9,700	15.00	8,630	10.00	425	38.00	3,014

¹Preliminary report from U. S. War Dept., Corps of Engineers, Mobile, Alabama, district.

²Approximately 5 miles upstream from mouth of Mobile River.

³Approximately 8.5 miles upstream from mouth of Mobile River at confluence with Big Bayou.

⁴Approximately 5 miles from mouth of Mobile River at bridge crossing Threemile Creek on Telegraph Road.

⁵Approximately 9 miles from mouth of Mobile River at bridge crossing Chickasaw Creek on Telegraph Road.

Store. The large difference in the chloride contained in the water from these wells is due to differences in the depth of the wells and the amounts of water pumped. Well S-9 yields 4 gallons per minute from a depth of 29 feet from the upper part of the aquifer, whereas well S-2 yields 360 gallons per minute from a depth of 60 feet from the lower part of the aquifer. A sample of water from well D-6, 717 feet deep at the First National Bank contained 1,060 parts per million of chloride, and a sample from well D-32, 750 feet deep at the United Ice Company contained 1,350 parts per million of chloride. The chloride in the deeper aquifer may be from salt water that was entrapped at the time the aquifer was formed, or it may be from salt water that is seeping into the aquifer as a result of pumping. From table 3 it is seen that there was no appreciable change in the chloride content of the deep well water during the period 1942 to 1945.

Ground water contaminated with appreciable amounts of sea water is generally unsatisfactory for cooling purposes. Continued use of highly-mineralized water frequently results in corrosion of the condenser tubes and in clogging of the tubes as a result of deposits of scale or of products of corrosion. The rate of corrosion is usually less in closed systems where little or no makeup water is required. This reduction in corrosion is largely the result of the exclusion of oxygen and other dissolved gases from the cooling system.

Under natural conditions, before the development of the well field, salt-water encroachment into the fresh-water aquifer was prevented by the presence of a sufficient head of fresh water above sea level, which was maintained by the heavy rainfall in the area. During the early period of development of the shallow ground water, when only a few wells were pumping, the recharge from rainfall was ample to replace the withdrawal, and the head of fresh water above sea level remained sufficient to prevent salt-water encroachment, except in a narrow zone along the river (pl. 1). Later, additional wells were drilled into the shallow aquifer, generally spaced only short distances from other wells (fig. 2). The ground-water reservoir was forced to yield more water as each new well was pumped for air-conditioning. In addition to this pumpage of ground water for air-conditioning, a well-point system was used to dewater the ex-

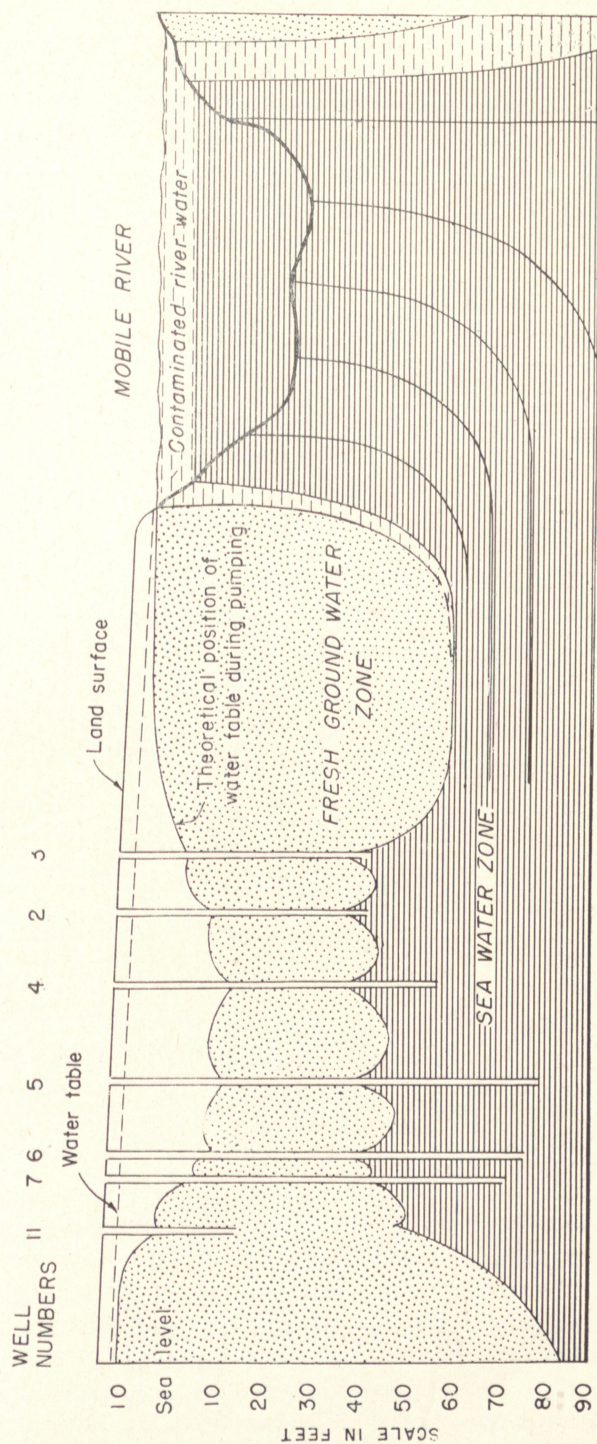


Figure 2. Water table during pumping affected by salt-water encroachment in aquifer.

cavation during the construction of the Bankhead Tunnel under the Mobile River (1941), further increasing the quantity of ground water withdrawn from the shallow aquifer. The withdrawal of ground water exceeded the amount replaced by recharge and the head of fresh water above sea level was lowered so that salt water began to flow into the shallow aquifer. The close spacing and alignment of the wells hastened and intensified this salt-water encroachment into the aquifer. The wells from which were pumped the greatest quantities of ground water had the highest concentration of chloride, owing to their greater drawdown (fig. 2 and table 2). The small air-conditioning units, which required smaller volumes of water from shallower wells, experienced less salt-water contamination. These wells pumped fresh water from the upper part of the aquifer (fig. 2, well 11; table 2, wells 9, 11, 18, 21, 22, and 23).

Following salt-water contamination of the air-conditioning wells, various parts of the air-conditioning equipment became corroded and condenser tubes were encrusted. Several users abandoned their wells at this time, and others used city water when the cost was not prohibitive. The larger establishments drilled deeper wells or changed to air-conditioning equipment of the cooling-tower type.

SUMMARY

Observation wells were located where changes of ground-water levels could be measured. The greatest annual fluctuation in water levels occurs in the shallow aquifer. When air-conditioning units were not in use, during the winter season, the water table at the observation wells was 2 feet or more above the level of the Mobile River. However, during the summer season, when air-conditioning units were in use, the water table was below the level of the Mobile River. When the water table was lowered below the river level during the summer season, the reduction in fresh-water head allowed the salt water of the river to gain entrance into the shallow aquifer. The well most distant from the Mobile River that is known to have been affected by salt water encroachment is well S-14 (pl. 1). The chloride in the water from this well increased from 950 parts per million in 1942 to 2,200 parts per million in 1945 (table 2).

The deeper aquifers down to 850 feet have shown little change in artesian pressure during the years 1942 to 1945. Likewise, the chloride content has not varied greatly. These aquifers are not overdeveloped or endangered at the present time. Well 32, owned by the Alabama United Ice Company, is 750 feet deep. In 1942 a sample of water from this well contained 1,370 parts per million of chloride; in 1945 an analysis of a sample from the same well showed 1,350 parts per million.

The shallow wells, 25 to 90 feet deep, in the downtown area of Mobile have been overdeveloped. The pumpage of the aquifer for air-conditioning, coupled with the withdrawal during the construction of the Bankhead Tunnel, has lowered the water table several feet below sea level at times and has resulted in the encroachment of salt water from the Mobile River. This salt water has entered the shallow aquifer in the entire downtown well field (pl. 1).

Whether the shallow aquifer can be restored is questionable. However, when other large users change either to deep wells or other types of air-conditioning equipment, the withdrawal of water from the shallow aquifer will be decreased, and a natural flushing of the shallow aquifer may result. The heavy rainfall, averaging 62 inches annually, and the favorable conditions for recharge of the aquifer tend to promote this result. To further enhance the probability of restoring fresh water to the shallow ground-water aquifer, it is suggested that its use be restricted to the smaller air-conditioning units. Wells for such units should be drilled to minimum depths possible, so that only the fresh water from the upper part of the aquifer will be withdrawn. Larger establishments that are using large amounts of shallow ground water could drill wells to the deeper aquifer, where a greater volume of water is available with less chloride content, or could use city water and a cooling tower.

The water sands 700 to 800 feet deep have possibilities of further development. Past records show little appreciable decline in pressure in this aquifer, although considerable quantities of water have been removed from it annually. Nevertheless, before each new deep well is drilled, the possibility of interference with an existing well now obtaining water from this aquifer

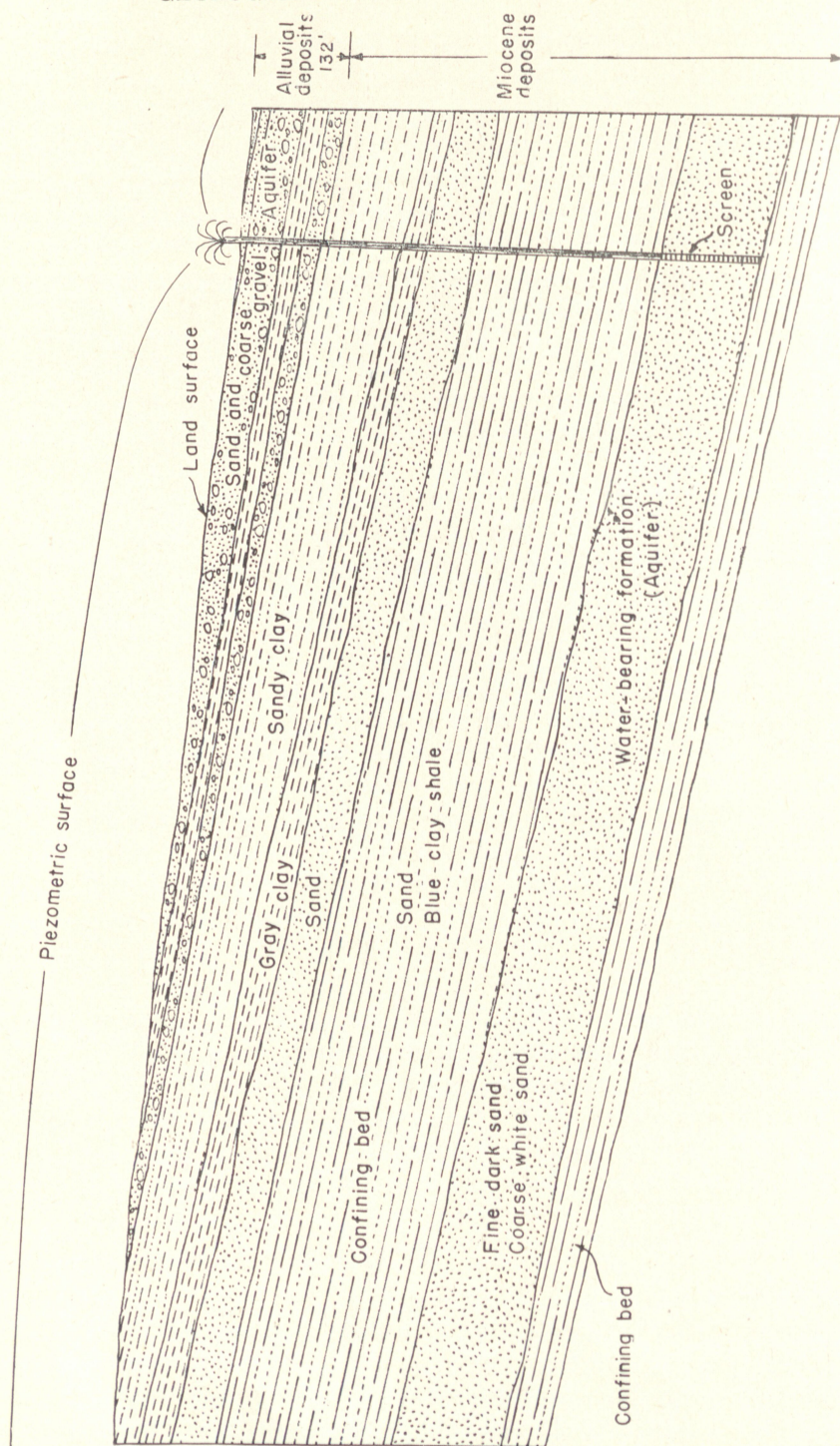


Figure 3. Artesian conditions in Mobile area.

should be considered, and the new wells should be located as far as possible from existing deep wells.

Another possible method of aiding restoration of the shallow aquifer is artificial recharge with water from the deep artesian aquifer. Some of the larger establishments that allow the artesian water to discharge into the sewer system of the city after it has been used for air-conditioning may be able to recharge a part of it into the shallow aquifer. The height at which this water is discharged in some places would allow recharge into the shallow aquifer without additional pumping costs.

Several wells tapping the deep ground water are allowed to flow freely when the water is not used. These wells should be regulated by valves, and only water that is needed for air-conditioning or other uses or for proper maintenance of the well should be allowed to flow. Abandoned flowing wells penetrating this aquifer should be plugged.

It is believed that the economic benefits resulting from proper measures of conserving both the shallow and the artesian water would be many times the cost.

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TABLE 2
DATA ON SHALLOW WELLS

Symbol S before well number signifies Shallow well. In many cases a company will have a shallow and deep well in the same location. The well number remains the same and the symbols S and D are used.

Well No.	Owner and location	Use of water	Diameter of casing (inches)	Depth of well	Temperature of water (° F.)	Gallons pumped per min. (est.)	Chloride content ² Yr.	Chloride content ² ppm	Dist. in ft. from possible source of salt water (from map)	Remarks	
S-1	Joe's Cafe, 62 Govt. St.	Air cond.	2	80	70	25	'42	14,700	750	75	Well originally 60 ft. deep. Aquifer dry during tunnel construction. Well 75' from excavation. Water became salty, owner now using city water.
S-2	Hammel's Dept. Store, 7 Royal St.	Air cond.	6	60	70	360	'42	7,250	950	575	Well drilled 1937. Owner noticed salt water intrusion summer 1941. Well, in use at present, frequent cleaning of coils necessary for operation. Owner plans drilling deeper well.
S-3	Metropolitan Auxiliary, 76 Dauphin Street	Air cond.	2	60	70	25	'42	6,350	850	800	Well abandoned late 1942. Owner using city water.
S-4	Battle House Hotel, SE corner Royal & St. Francis Sts.	Air cond.	6	67	70	---	'42	3,910	1,030	1,020	Well drilled 1900, abandoned prior to salt-water encroachment.

TABLE 2—Continued

Well No.	Owner and location	Use of water	Diameter of casing (inches)	Depth of well	Temper- water (° F.)	Gallons pumped per min. (est.)	Chloride content ² Yr. ppm	Chloride content ² Yr. ppm	Dist. in ft. from possible source of salt water (from map)	Remarks
S-5	Gulf, Mobile & Ohio RR Co., NW corner Royal & St. Francis Streets	Air cond.	8	90	71	420	'42	6,890	1.230	Well drilled 1941, abandoned late 1942. Deeper well drilled.
S-6	1st Natl. Bank, SE corner St. Joseph & St. Francis Sts.	Air cond.	10	90	70	800	'42	6,100	1.350	Well drilled 1937, abandoned late 1943. Deeper well drilled.
S-7	Merchants Natl. Bank, NE corner St. Joseph & St. Francis Sts.	Air cond.	8	75	72	400	'42	400	1.400	Well drilled Feb. 1939, operating at present time.
S-8	Coca-Cola Co., 200 N. Royal	Industrial	6	67	71	100	'38	140	1.210	Well drilled 1938, abandoned 1941 owing to high chloride content.
S-9	Morgan Plan Bank, opposite P. O. Building	Air cond.	2	29	72	4	'42	54	1.470	Low chloride content maintained owing to shallow depth and small draw-down.
S-10	Constantine's Restaurant, 11 N. Royal St.	Air cond.	3	75					1.170	Well abandoned at time of construction of tunnel, 1941. Using city water.

S-11	Ryan Stevedore Co., 55 St. Joseph St.	Air cond.	2	30	72	4	'42	74	'45	61	1,550	1,200	Low chloride content due to shallow depth and small draw- down.
S-12	LaClede Cafe, 156 Govt. Street	Air cond.	2	60	72	15	'42	2,330	'45	4,900	1,430	120	Owner operating at present with ground water.
S-13	Greyhound Bus Station, SW cor. Conception & Govt. Sts.	Air cond.	---	---	---	---	---	---	'45	6,820	1,620	430	Owner using city water, abandoned well 1945. Coils cor- roded and air-con- ditioning equipment did not operate on well water.
S-14	Admiral Semmes Hotel, SW corner Govt. and Joachim Sts.	Air cond.	8	90	71	400	'42	950	'45	2,200	1,985	790	Owner using ground water, plans change in equipment.
S-15	Walgreen Drug Store, NE corner Dauphin & St. Joseph Sts.	Air cond.	6	60	---	60	---	---	---	---	1,285	790	Owner using city water, discontinued use of ground wa- ter late 1942.
S-16	Baker's Shoe Store, 155 Dauphin St.	Air cond.	2	67	73	25	'42	264	'45	2,490	1,470	670	Operating at present with ground water.
S-17	Kabers Shoe Store, 119 Dauphin St.	Air cond.	2	50	---	20	---	---	'45	1,770	1,235	660	Operating at present with ground water.
S-18	Betty Gay Shop, 161 Dauphin St.	Air cond.	3	---	73	20	---	---	'45	30	1,500	650	Operating at present with ground water.
S-19	Mangel's, 167 Dauphin Street	Air cond.	2	60	---	25	---	---	---	---	1,570	660	Now using city wa- ter, well filled with sediment.

TABLE 2—Continued

Well No.	Owner and location	Use of water	Diameter of casing (inches)	Depth of well	Temperature of water (° F.)	Gallons pumped per min. (est.)	Chloride content ² Yr.	Chloride content ² Yr.	Dist. in ft. from possible source of salt water (from map)	Remarks
S-20	Stein's, 201 Dauphin St.	Air cond.	2	30	72	15	---	---	1,790	750 Now using city water, well filled with sediment.
S-21	Cotton Shop, 201½ Dauphin St.	Air cond.	1¼	30	72	10	---	'45	1,860	780 Operating at present with ground water.
S-22	Harris Jewelry, 203 Dauphin St.	Air cond.	1¼	30	72	15	---	'45	1,900	820 Operating at present with ground water.
S-23	Schwob Clothes, 211 Dauphin St.	Air cond.	2	---	---	15	---	'45	1,950	840 Operating at present with ground water.
S-24	Harry Shoe Store, 276 Dauphin St.	Air cond.	1¼	60	71½	10	---	'45	2,300	1,150 Operating at present with ground water.
S-25	Century Theatre, 208 Dauphin St.	Air cond.	4	70	---	---	---	---	1,890	900 Using city water, coils replaced on equipment owing to corrosion.
S-26	Bert's Beauty Shop, 16 S. Joachim	Air cond.	1¼	27	---	---	---	---	2,120	920 Using city water, well filled with sediment.
S-27	DeVan Motor Company, 205 St. Joseph	Air cond.	2	65	---	20	'41	8	1,670	2,100 Using city water, owing to difficulty with well.
S-28	Azalea Grill, 200 St. Francis	Air cond.	2	---	---	---	---	---	1,940	1,220 Not in operation. Well clogged.

S-29	Cawthon Hotel, 25 N. Conception	Air cond.	2	70-80	72	14	'42	40	---	1,900	1,100	Well abandoned owing to faulty well construction.	
S-30	Gayfers Dept. Store, 12 St. Emanuel	Air cond.	6	62	70	175	'42	2,760	'45	6,050	530	Plan change in air-conditioning methods, present system not operating satisfactorily.	
S-33	Peoples Ice Co., Palmetto St.	Condensing	4	55	70	200	'42	370	---	850	2,600	Well abandoned. Water fresh originally, became contaminated with sea water after used for a time.	
S-35	The Texas Co., Virginia Street	Industrial	4	80	71	---	---	---	---	500	7,100	Well abandoned prior to 1942.	
S-37	Oakdale Ice & Fuel Co. Ice manufacture		6 & 10	87	73	575	'42	18	'45	16	3,200	8,100	Drilled 1940. No increase in chloride since that time. Original water level 12.0 ft. below surface.
S-62	Alcoa Steamship Co.	Industrial	2	65	70	25	'42	2,470	---	100	3,070	Additional information not obtained 1945.	
S-64	Crystal Ice Co., 806 S. Monroe	S. Ice manufacture	4	87	70½	280	'41	48	'45	29	4,400	4,900	Drilled 1941, has operated satisfactorily since that time. No increase in chloride.

¹Estimated quantity pumped when air-conditioning unit in operation.

²Field determinations made under variable conditions; values approximate.

TABLE 3

DATA ON DEEP (ARTESIAN) WELLS

Symbol D before well number signifies Deep well. In many cases a company will have a deep and shallow well in the same location. The well number remains the same and the symbols S and D are used.

Well No.	Owner and Location	Use of Water	Diameter of casing (inches)	Depth of well (feet)	Temp. of water (° F.)	Gallons of water used per minute (est.) ¹	Chloride Content ² Yr. ppm	Chloride Content ² Yr. ppm	Dist. in ft. to nearest well pumping from same River	Remarks
D-5	G.M.&O. RR Co., NW corner Royal & St. Francis Sts.	Air cond.	12 & 6	676	76	500	---	'45 1,100	200	1,230 Original depth 743 ft., drilled 1943. Owning to screen failure redrilled in 1944 to present depth. Artesian pressure 23 lbs./sq. in., no decrease in pressure since placed in use.
D-6	First Natl. Bank, SE cor. St. Joseph & St. Francis Sts.	Air cond.	10	717	76	800	---	'45 1,060	200	1,350 Drilled 1944, has operated satisfactorily since. Artesian pressure 14 lbs./sq. in., no change in pressure since drilled.
D-32	Ala. United Ice Co., NE corner Royal & Theatre Sts.	Condensing	6	750	77	1,100	'42 1,370	'45 1,350	1,350	680 Drilled 1908, used since that time. No change in chloride content. Flowing well, no regulation of flow.
D-34	Ala. United Ice Company, Elmira Street	Condensing	8	351	78	350	'42 1,516	'45 1,370	1,800	1,000 Used since drilled in 1925. Flowing well, no regulation of flow.

GROUND-WATER INVESTIGATIONS IN MOBILE AREA

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D-36	Ala. Naval Stores Co., Choctaw Point	6	157	72	400	'42	344	800	When drilled 1933 water level 7 feet below land surface.
D-38	Crystal Swimming Pool (City of Mobile), S of US Coast Guard Sta.	6	675	77	350	'42	600	500	Flowing well, now abandoned. Casing corroded.
D-39	Fulton Ice Co., Govt. St. at Fulton Rd.	10	138	70	280	'42	16	12,700	Satisfactory supply since 1933.
D-39a	Fulton Ice Co., Govt. St. at Fulton Rd.	12	270	70	500	---	---	12,700	Drilled 1943. Water level 33 ft. below land surface.
D-40	Tacon Ice Co., Dauphin St. at Tacon Station	6	105	69	250	'42	18	2,930	Ice manufacture dis- continued at this plant.
D-59	Star Fish & Oyster Co., W bank Industrial Canal	6	595	74	160	'42	1,170	100	Natural flow approx. 160 gal./min. Own- er drilling additional well.
D-60	Coastal Petroleum Co., Blakely Is., opposite State Docks	6	270	71	60	'42	357	120	Not in use in 1945.
D-61	Mobile Brewery Ice Co. SE cor. Water & State Sts.	8	749	77	160	'42	2,475	200	Natural flowing well, no regulation of flow.
D-63	Mobile Gas Co., Davis Avenue	8	155	520				5,400	Water level 10.0 ft. below surface when drilled in 1927.

¹Estimated quantity of water pumped when air-conditioning units in operation.²Field determinations made under variable conditions; values approximate.

TABLE 4
CHEMICAL ANALYSES OF GROUND WATER
(Parts per million)¹

Well No.	Owner and Location	Date	Depth of Well (feet)	Total hardness as CaCO ₃	Bicarbonate (HCO ₃)	Chloride (Cl)	Sulfate (SO ₄)	Nitrate (NO ₃)	Fluoride (F)	Remarks
S-2	Hammels Dept. Store, 7 S. Royal Street	9-15-45	60	3,490	435	8,650	980	22	0.3	Brown color, contained iron sediment.
S-7	Merchants National Bank, NE cor. St. Joseph & St. Francis Sts.	9-17-45	75	1,440	92	3,880	473	16	0.1	Contained some iron sediment.
S-9	Morgan Plan Bank, opposite P.O. Bldg.	9-15-45	29	100	23	52	90	20	0.1	Iron sediment.
S-12	LaClede Cafe, 156 Govt. St.	9-15-45	60	1,700	120	4,900	580	10	---	Very slight sediment.
S-30	Gayfers Dept. Store, 12 St. Emanuel	9-15-45	62	2,620	23	6,050	803	5.4	0	Iron sediment.
S-37	Oakdale Ice & Fuel Co., 900 S. Broad	9-15-45	87	18	40	13	11	10	0.1	Very slight black sediment.
S-64	Crystal Ice Co., 806 Monroe	9-15-45	87	58	3.0	29	53	30	0.2	Water clear, well 250 ft. S of a cemetery.
D-5	G. M. & O. RR Co., NW cor. Royal & St. Francis Sts.	9-15-45	676	36	439	1,100	---	---	---	Slight sediment.
D-6	First National Bank, SE cor. St. Joseph & St. Francis Sts.	9-15-45	717	39	444	1,060	3	---	---	Some sediment.
D-32	Ala. United Ice Co., NE cor. Royal & Theatre Sts.	9-15-45	750	50	505	1,350	---	---	---	Very slight sediment.
D-39a	Fulton Ice Co., Govt. St. at Fulton Road	9-17-45	270	12	5.0	8	6	0.1	0.1	Slight iron sediment.

¹Analyzed by V. T. McNamara and Evelyn Holloman of the U. S. Geological Survey.

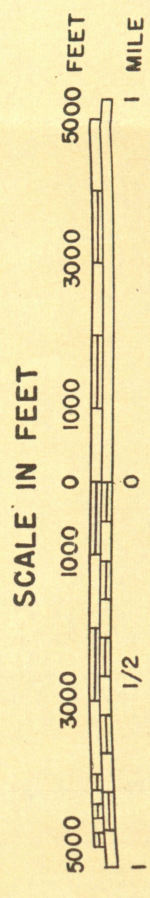
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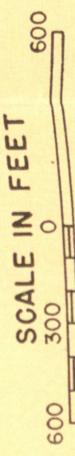




Plate I MAP OF MOBILE, ALABAMA



DOWNTOWN AREA



EXPLANATION

- Nonflowing well
- Flowing well with pumping plant
- ⊙ Nonflowing observation well
- ⊕ Flowing well with pumping plant under observation
- ▨ Area of salt water encroachment prior to pumping
- ▩ Area of salt water encroachment at present time

